CLAIMS

What is claimed is:

1. A semiconductor milling endpoint detection system comprising:

a focused ion beam (FIB) apparatus for directing a focused ion beam at an integrated circuit sample, wherein a charge pulse is generated each time an ion from the beam strikes the sample;

a plurality of charge pulse detection electronics (CPDE) components, wherein the CPDE components are coupled to the sample; and

a histogram display.

2. The endpoint detection system of claim 1, wherein the CPDE components comprise:

a charge preamplifier directly coupled to a layer of interest within the sample and configured to amplify and integrate the charge pulse to produce a voltage pulse indicative of the size of the charge pulse;

a pulse amplifier directly coupled to the charge preamplifier and configured to amplify the voltage pulse;

a pulse shaper directly coupled to the pulse amplifier and configured to optimize the shape of the voltage pulse to a height proportional to the charge pulse; and

a multi-channel analyzer (MCA) directly coupled to the pulse shaper and configured to detect the height of the shaped pulse and sort the shaped pulse into one of a plurality of channels, wherein each channel is associated with a range of shaped pulse heights.

3. The endpoint detection system of claim 1, wherein the histogram display comprises:

an X-axis divided into a plurality of channels;

a Y-axis representing an event count, wherein an event is generated each time an ion strikes the sample;

a distribution curve, wherein the curve is formed by plotting each event into the appropriate channel based on the height of each shaped pulse.

4. The endpoint detection system of claim 3, wherein the system can be calibrated by milling a reference sample similar in construction to the integrated circuit sample and obtaining a reference curve for each layer within the reference sample.

5. The endpoint detection system of claim 4, wherein a noticeable shift in the distribution curve indicates that milling has completed on a layer within the sample.

6. The endpoint detection system of claim 5, wherein a milling endpoint can be detected by comparing the distribution curve formed immediately prior to the shift with the reference curves.

7. The endpoint detection system of claim 3, wherein the histogram display can be refreshed on command.

8. The endpoint detection system of claim 1, wherein the CPDE components comprise:

a charge preamplifier, wherein the charge preamplifier is directly coupled to a layer of interest within the sample;

a pulse shaper directly coupled to the charge preamplifier;

a pulse amplifier directly coupled to the pulse shaper; and

a multi-channel analyzer (MCA) directly coupled to the pulse amplifier.

9. The endpoint detection system of claim 1, wherein the CPDE components comprise:

a charge preamplifier is directly coupled to a layer of interest within the sample;

a spectroscopy amplifier directly coupled to the charge preamplifier; and

a multi-channel analyzer (MCA) directly coupled to the spectroscopy amplifier.

10. A method for detecting a focused ion beam milling endpoint on a semiconductor sample comprising:

striking an integrated circuit sample with an ion beam generated by a focused ion beam (FIB) apparatus;

utilizing a plurality of charge pulse detection electronics (CPDE) components to detect and configure a charge pulse generated each time an ion from the beam strikes the sample; and

creating a distribution curve on a histogram display based on output of the CPDE components.

11. The method of claim 10, wherein the CPDE components comprise:

a charge preamplifier directly coupled to a layer of interest within the sample and configured to amplify and integrate the charge pulse to produce a voltage pulse indicative of the size of the charge pulse;

a pulse amplifier directly coupled to the charge preamplifier and configured to amplify the voltage pulse;

a pulse shaper directly coupled to the pulse amplifier and configured to optimize the shape of the voltage pulse to a height proportional to the charge pulse; and

a multi-channel analyzer (MCA) directly coupled to the pulse shaper and configured to detect the height of the shaped pulse and sort the shaped pulse into one of a plurality of channels, wherein each channel is associated with a range of shaped pulse heights.

12. The method of claim 10, wherein the histogram display comprises:

an X-axis divided into a plurality of channels;

a Y-axis representing an event count, wherein an event is generated each time an ion strikes the sample;

a distribution curve, wherein the curve is formed by plotting each event into the appropriate channel based on the height of each shaped pulse.

13. The method of claim 12, wherein the histogram display can be calibrated by milling a reference sample similar in construction to the integrated circuit sample and obtaining a reference curve for each layer within the reference sample.

14. The method of claim 13, wherein a noticeable shift in the distribution curve indicates that milling has completed on a layer within the sample.

15. The method of claim 14, wherein a milling endpoint can be detected by comparing the distribution curve formed immediately prior to the shift with the reference curves.

16. The method of claim 12, wherein the histogram display can be refreshed on command.

17. The method of claim 10, wherein the CPDE components comprise:

a charge preamplifier, wherein the charge preamplifier is directly coupled to a layer of interest within the sample;

a pulse shaper directly coupled to the charge preamplifier;

a pulse amplifier directly coupled to the pulse shaper; and

a multi-channel analyzer (MCA) directly coupled to the pulse amplifier.

18. The method of claim 10, wherein the CPDE components comprise:

a charge preamplifier is directly coupled to a layer of interest within the sample;

a spectroscopy amplifier directly coupled to the charge preamplifier; and

a multi-channel analyzer (MCA) directly coupled to the spectroscopy amplifier.

19. An integrated circuit sample milled according to a process comprising the steps of:

striking the sample with an ion beam generated by a focused ion beam (FIB) apparatus;

detecting and configuring a charge pulse generated each time an ion from the beam strikes the sample with a plurality of charge pulse detection electronics (CPDE) components; and

generating a distribution curve on a histogram display based on output of the CPDE components.

20. The sample of claim 19, wherein the CPDE components comprise:

a charge preamplifier directly coupled to a layer of interest within the sample and configured to amplify and integrate the charge pulse to produce a voltage pulse indicative of the size of the charge pulse;

a pulse amplifier directly coupled to the charge preamplifier and configured to amplify the voltage pulse;

a pulse shaper directly coupled to the pulse amplifier and configured to optimize the shape of the voltage pulse to a height proportional to the charge pulse; and

a multi-channel analyzer (MCA) directly coupled to the pulse shaper and configured to detect the height of the shaped pulse and sort the shaped pulse into one of a plurality of channels, wherein each channel is associated with a range of shaped pulse heights.

21. The sample of claim 19, wherein the histogram display comprises:

an X-axis divided into a plurality of channels;

a Y-axis representing an event count, wherein an event is generated each time an ion strikes the sample;

a distribution curve, wherein the curve is formed by plotting each event into the appropriate channel based on the height of each shaped pulse.

22. The sample of claim 21, wherein a noticeable shift in the distribution curve indicates that milling has completed on a layer within the sample.

23. The sample of claim 22, wherein a milling endpoint can be detected by comparing the distribution curve formed immediately prior to the shift with the reference curves.